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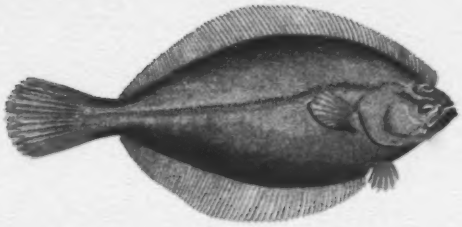
Gulf Region

Canadian Science Advisory Secretariat
Science Advisory Report 2016/031

STOCK ASSESSMENT OF AMERCIAN PLAICE (*HIPPOGLOSSOIDES PLATESSOIDES*) OF THE SOUTHERN GULF OF ST. LAWRENCE (NAFO DIV. 4T) TO 2015



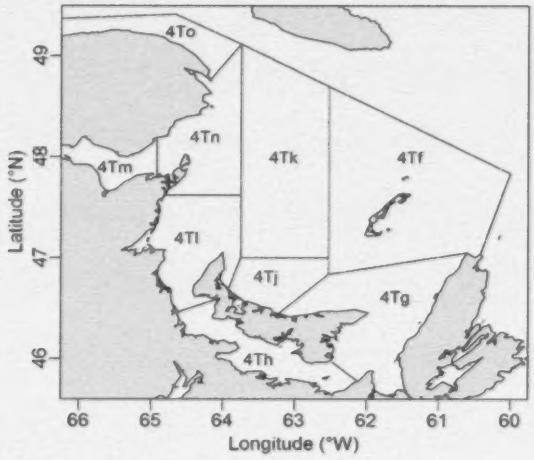


Figure 1. Subdivisions within NAFO Div. 4T in the southern Gulf of St. Lawrence.

Context:

American plaice (Hippoglossoides platessoides) is a righteye flounder whose distribution spans the North Atlantic Ocean. In the Western Atlantic, the species ranges from 40°N in the United States to above the Arctic Circle. In Canadian waters, the species is divided in a number of different stocks including the southern Gulf of St. Lawrence stock in NAFO division 4T. American plaice in the southern Gulf of St. Lawrence was once an abundant resource and supported an extensive commercial fishery. In the 1980s, it was the most important commercial flatfish fishery in the Gulf of St. Lawrence. The resource then declined substantially during the 1990s and now supports a very modest fishery.

An annual total allowable catch (TAC) of 250 t for American plaice has been in effect since 2012 in NAFO Division 4T. DFO Ecosystems and Fisheries Management has instituted a multi-year management approach for American plaice and requested advice for a TAC decision for May 2016 to May 2021 for the southern Gulf of St. Lawrence American plaice stock.

This Science Advisory Report is from the March 1 and 2, 2016 science peer review meeting on the stock status of American plaice and the development of management advice for the fishery on this stock. Participants at the meeting included DFO Science (Gulf, Newfoundland and Labrador regions), DFO Fisheries Management (Gulf and Quebec regions), and the fishing industry.

July 2016

Canada

SUMMARY

- American plaice is currently caught as bycatch in fisheries primarily directed for witch flounder and Greenland halibut. Preliminary landings in 2015 were 40 t.
- There has been a decrease in the size of American plaice with the mean length decreasing from around 25 cm prior to 1995 to 21.3 cm during the 2011 to 2015 time period. The mean length and weight at age of American plaice have also decreased.
- Natural mortality for American plaice ages 4 to 9, decreased from about 53% (annual mortality) in the late 1970s to about 39% since 2005. The estimated natural mortality for plaice aged 10+ increased from 22% in the 1970s to greater than 39% since 1995.
- The median estimate of spawning stock biomass (SSB) was about 350 kt in the late 1970s decreasing rapidly to 100 kt or less by 1984. Estimated SSB was estimated at 55 kt in 2015.
- The stock has been in the critical zone since 1993. In 2015, the median of the SSB estimate was 40% of the limit reference point (LRP) with essentially zero chance of the SSB being above the LRP.
- Fully recruited exploitation rate on age 10+ was estimated to have peaked in 1992 at just over 26% but has been less than 1% in the recent five years. Fishing mortality is a very small proportion of the total mortality (natural plus fishing) of American plaice of the southern Gulf of St. Lawrence.
- Under current productivity conditions, the SSB is expected to remain in the critical zone with essentially zero chance of the SSB being above the LRP during 2016 to 2021 at TAC options of 0 t, 100 t, or 250 t.
- The rebuilding prospects for this stock under current conditions are low because of the high level of natural mortality. Predation by grey seals is thought to be a major component of the high level of natural mortality.

INTRODUCTION

American plaice (*Hippoglossoides platessoides*) is a flatfish which is broadly distributed in the western Atlantic, ranging from 40°N in the United States to above the Arctic Circle. In Canadian waters, the species is managed as different stocks including the southern Gulf of St. Lawrence (sGSL) stock which is defined by NAFO Division 4T. American plaice exhibits sexually dimorphic growth with asymptotic length for females of 58.6 cm versus 35.6 cm for males. It is a moderately long-lived species with a maximum estimated age in the sGSL of 18 years. It is broadly distributed at all depths in the sGSL.

In 2010, the Committee for the Status of Endangered Wildlife in Canada (COSEWIC) assessed American plaice from the sGSL as being part of the Maritime Designatable Unit (including American plaice in NAFO Divs. 4RS and 4VWX) and assessed its status as threatened. The status of American plaice in the sGSL was last reviewed in February 2012 as part of a Recovery Potential Assessment and the establishment of the Limit Reference Point (LRP) for this stock (DFO 2011; DFO 2012c; Morin and LeBlanc 2012; Morin et al. 2013).That review, using data to 2011, concluded that the 4T stock of American plaice was at an all-time low level of abundance and had been below the LRP since 1993 (except in 2004). Updates of indicators of abundance were provided for 2013 and 2014 (DFO 2014; DFO 2015).

The Fisheries

American plaice landings in NAFO Div. 4T ranged between 6,000 tonnes and 12,000 tonnes during the 1960s to the late 1980s (Fig. 2). The reported landings do not account for the discarding that was a common practice in the mobile gear plaice fishery until 1993. A total allowable catch (TAC) of 10,000 t was first introduced in 1977. It was reduced to 5,000 t in 1993 and progressively lower values afterwards, to 250 t since 2012.

Starting in 1993, the fishing effort on American plaice and the landings were greatly reduced because of the introduction of management measures (quota reduction and increased mesh size for mobile gear). The cod fishery moratorium that was in place during 1993 to 1998 also reduced the fishing effort on groundfish stocks, including American plaice (Fig. 3). American plaice landings have steadily declined and in recent years have been at their lowest historical level. Total preliminary reported landings in 2015 from quota monitoring were 43 t, although the preliminary value from the Zonal Interchange File Format (ZIFF) database used in this assessment was 40 t (Fig. 2).

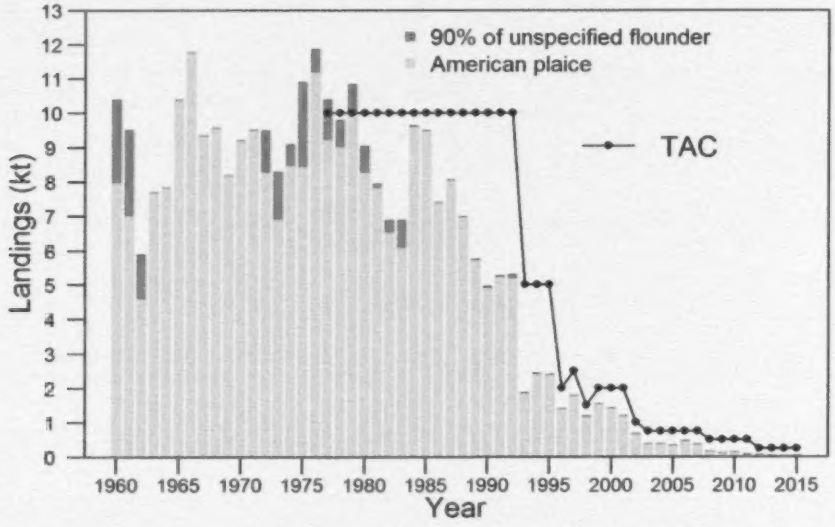


Figure 2. Reported annual landings of American plaice and total allowable catch (TAC) in NAFO Div. 4T. The landings estimates include at-sea discards during the 1970s and 1980s as well as 90% of landings marked as "unspecified flounder".

During 1985 to 2007, the majority of American plaice catches were reported from mobile gears (trawls and seines) but since 2013 gillnets have proportionally captured more American plaice than other gears (Fig. 3).

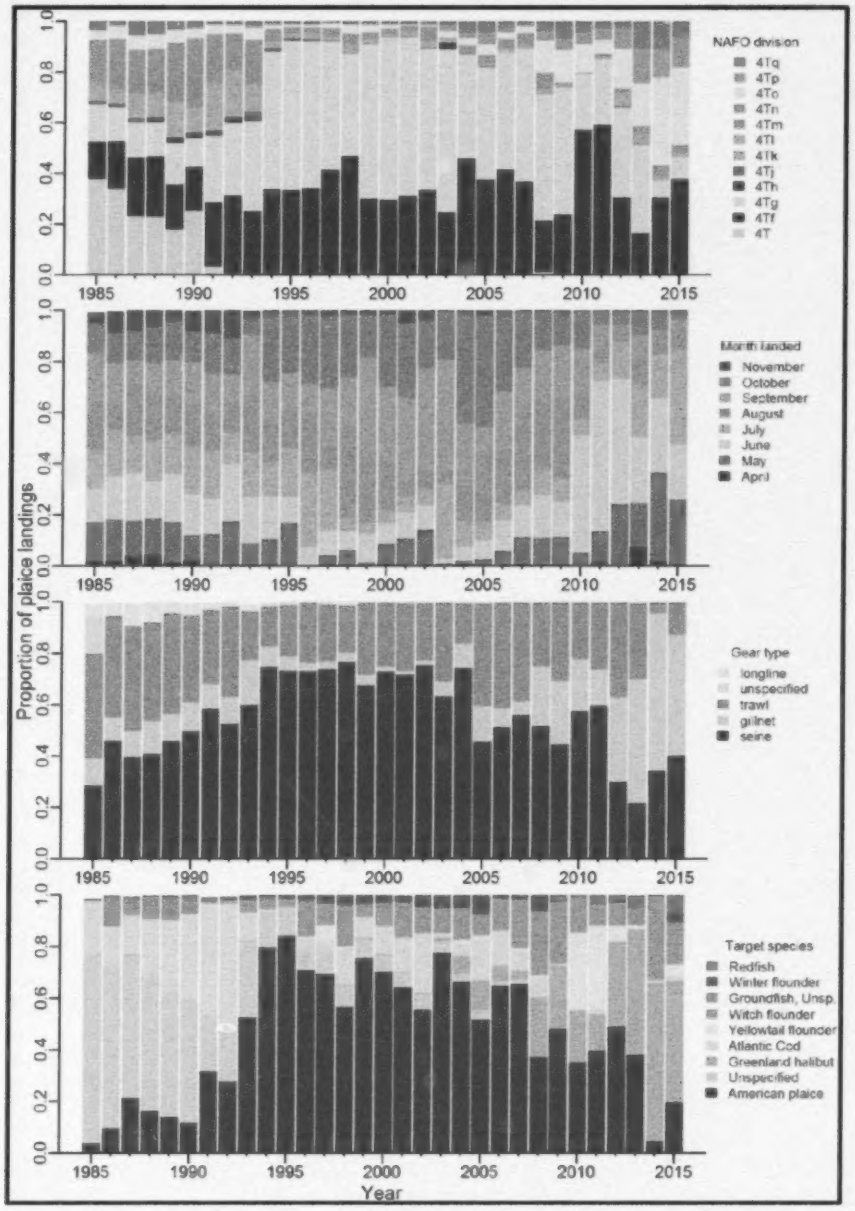


Figure 3. Proportion of annual American plaice landings by NAFO 4T subdivision (upper row), by month (second panel), by type of fishing gear (third panel) and by target fishing species (lower panel), 1985 to 2015.

Whereas historically American plaice were more broadly captured in the both eastern and western areas of the sGSL, the low landings of American plaice in 2012 to 2015 have been reported primarily as by-catch in the witch flounder fishery by mobile gear off Cape Breton and the Greenland halibut fishery exploited by gillnetters off the Gaspe coast (Figs. 3 and 4).

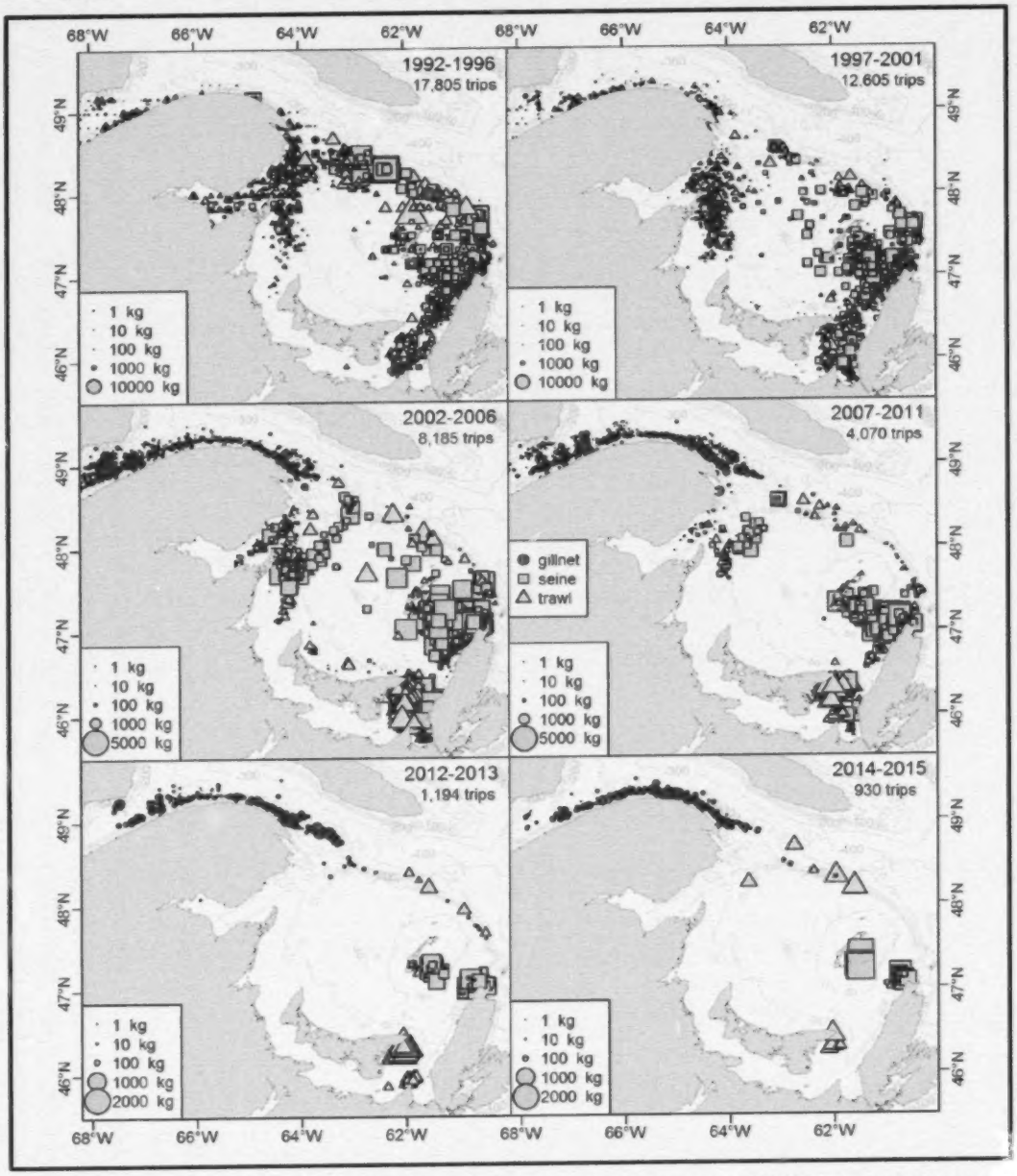


Figure 4. Geographic location of catches of American plaice by gear type in NAFO Div. 4T, 1992 to 2015.

ASSESSMENT

Abundance Indices

A research vessel (RV) bottom trawl survey has been conducted in the sGSL (Fig. 1) using standardized protocols each September since 1971. In addition, a sentinel August otter trawl

survey has been conducted since 2003. Results of these surveys provide information on trends in abundance and biomass for groundfish species in the 4T area.

The September RV survey of the sGSL follows a stratified random sampling design. The same stratification scheme has been used since 1971, except for the addition of three inshore strata (401-403) in 1984. Comparative fishing experiments were conducted to test for species-specific changes in fishing efficiency whenever there was a change in research vessel (1985, 1992, and 2004/2005) or trawl gear (1985). Furthermore there was a change from day only to 24-hr fishing in 1985, and both comparative fishing experiments and analyses of survey catches have been undertaken to estimate any species-specific changes in fishing efficiency that resulted from this change in protocol. When a change in fishing efficiency was detected for a particular species, catch rates for that species were standardized to a constant level of efficiency so that indices remained comparable for the entire time series (Benoît and Swain 2003; Benoît 2006).

The RV survey abundance index for pre-commercial sized (< 30 cm) American plaice increased sharply in the 1970s then decreased sharply to a long-term average value in 1983 (Fig. 5). Abundance continued to decline and attained the lowest values of record in the early 2000s. Abundance has increased slightly into 2015 but the indices remain below the long term average value. The same trend in abundance was noted for commercial sized American plaice (>= 30 cm), peaking in the late 1970s and declining to below long term mean level by the early 1990s to record low values in 2008 to 2012. The value in 2015 is slightly improved from 2012 but remains wells below the long term mean value (Fig. 5).

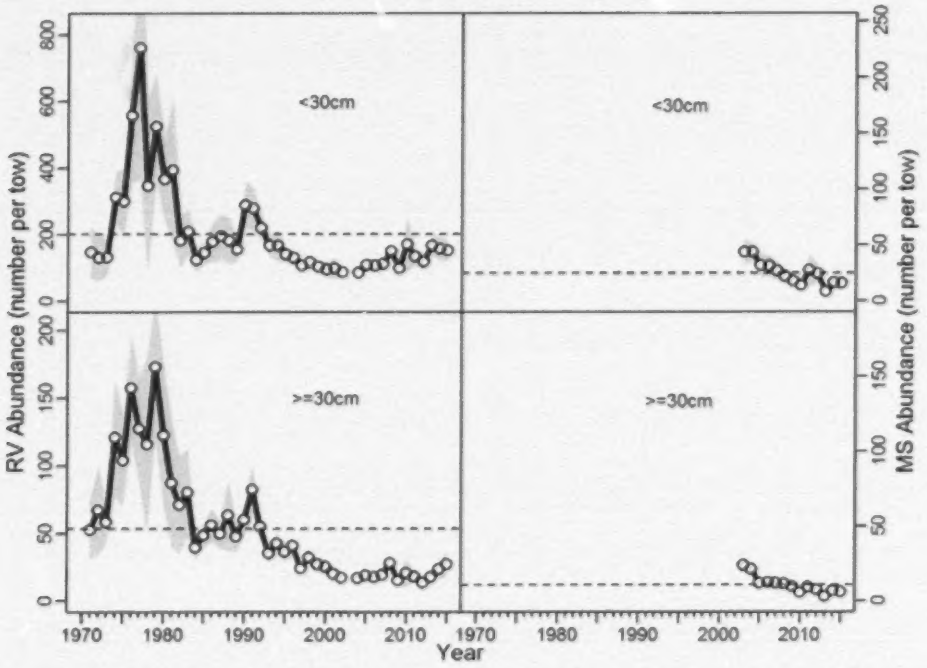


Figure 5. Survey abundance (stratified number per tow) of American plaice < 30 cm (top row) and >= 30 cm (lower row) from the RV survey (left column) and the Mobile Sentinel survey (MS; right column) of the southern Gulf of St. Lawrence. The horizontal dashed lines in each panel show the means of the indices for the total time series and the shaded area represents 95% confidence interval. Data from 2003 for the RV survey are omitted from the figure as an uncalibrated vessel was used that year.

Length-frequency distributions show a reduction in the size of American plaice caught in the September survey (Fig. 6). During 1971 to 1995, American plaice mean lengths were between 25 and 26 cm. Since 1996, mean lengths have progressively decreased to a mean value of 21.3 cm during the 2011 to 2015 time period (Fig. 6). Large plaice, greater than 40 cm continue to be captured in the sGSL in September, although the percentage of this size group in the sampled catches declined from almost 5% in the early 1970s to less than 1% by 2001 (Fig. 6).

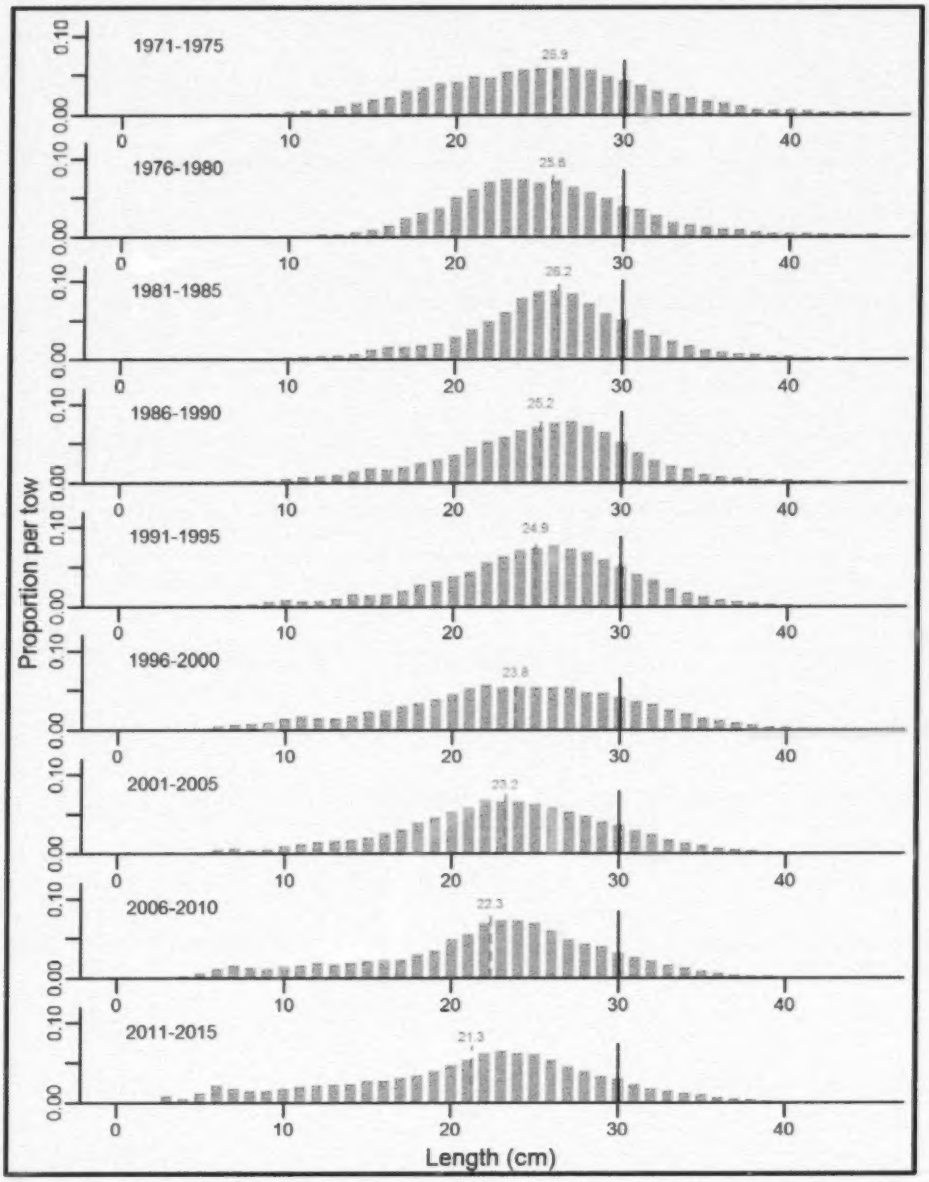


Figure 6. Length frequency distributions of American plaice in the annual Southern Gulf of St. Lawrence bottom trawl survey by 5-year periods. The mean length is shown as the red dashed vertical line and the solid line is the 30 cm commercial size.

Size at Age

Size at age of both male and female American plaice in the sGSL has declined, and consequently so did mean weight at age (Fig. 7). The mean weight of American plaice over the period 1976 to 2015 declined by 11% for age 6, 24% for age 8, 37% for age 10 and 55% for age 12 fish.

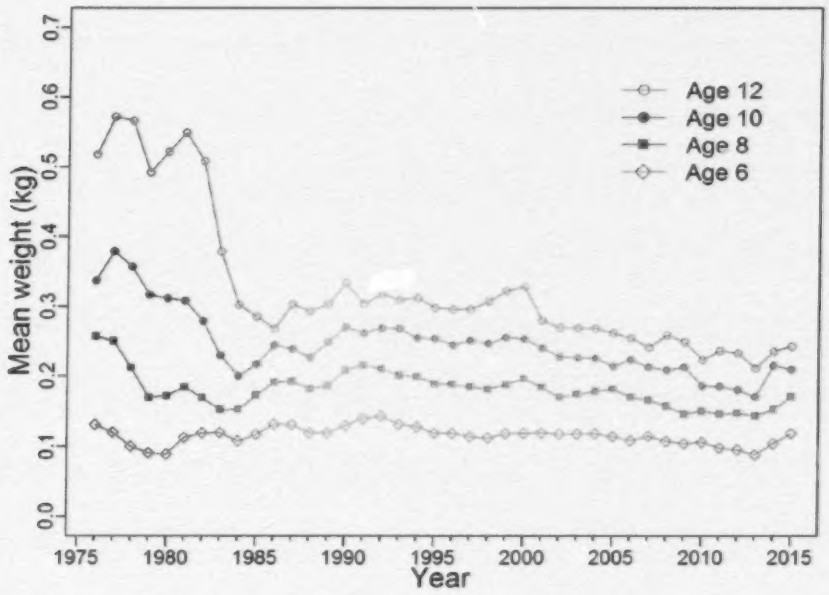


Figure 7. Mean weight-at-age (kg) of American plaice (sexes combined) for example ages 6, 8, 10, and 12 years, from the annual southern Gulf of St. Lawrence September RV bottom trawl survey, 1976 to 2015.

Spatial Distribution

There is no apparent change in the spatial distribution of American plaice in the sGSL over the time series. American plaice, size groups, male and female, show sustained broad distribution in the sGSL in September (Fig. 8).

Population modelling

The current assessment uses an age-structured virtual population model to estimate abundance (Ricard et al. 2016). The catch-at-age matrix from the fishery encompasses ages 4 to 16+, 1976 to 2015 (Fig. 9). The fishery-independent age-specific indices were from the RV survey and the mobile sentinel survey. Ages were modelled from 4 to 16+ for the years 1976 to 2015. Annual natural mortality was estimated for two age groups (4-9 and 10+) as a random walk.

The model estimated age-specific abundance and the corresponding survey-derived estimates (corrected for survey catchability) are shown in Figure 10. The model fits for ages 4 to 6 are relatively good but the abundances of ages 11 to 16+ tended to be overestimated during 1976 to 1984.

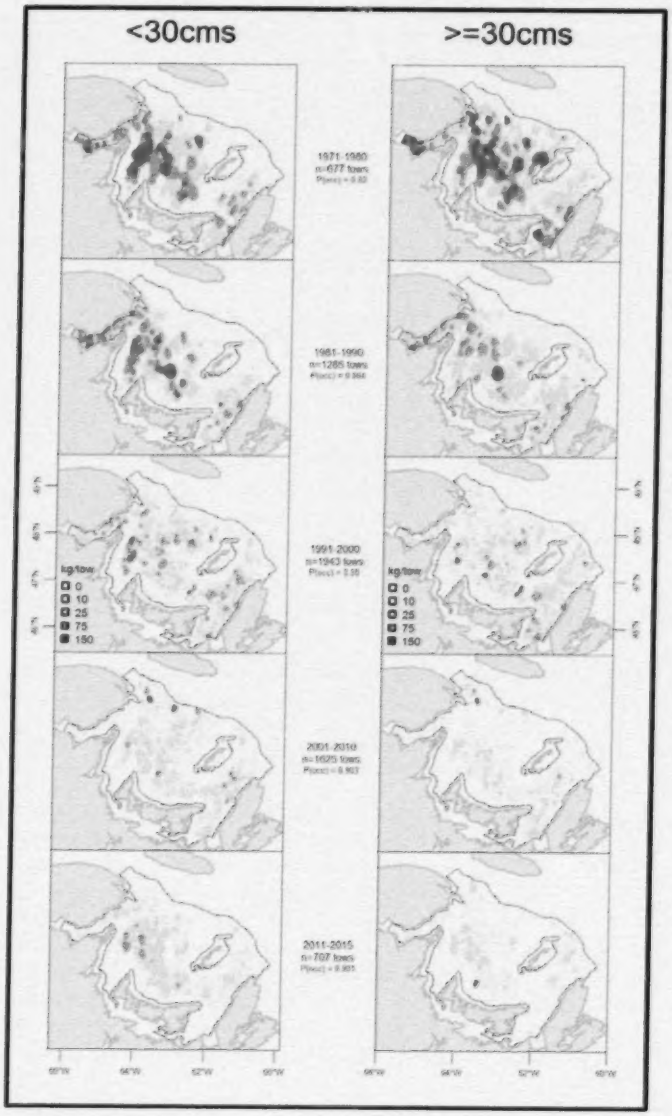


Figure 8. Distribution maps of American plaice catch rates (kg/tow) by size group (< 30 cm left column, >= 30 cm right column) in the annual Southern Gulf of St. Lawrence RV bottom trawl survey by 10-year periods, five year group for the 2011-2015 period. In each panel, P(occ) is the proportion of tows in which American plaice were captured.

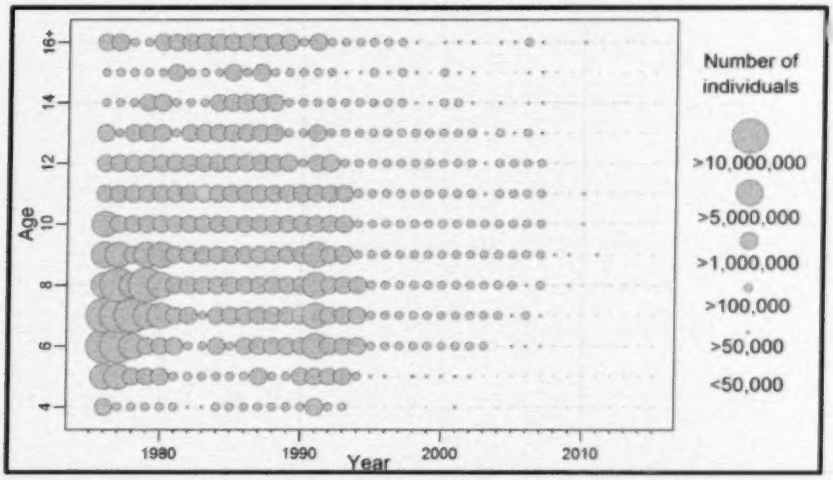


Figure 9. Bubble plot of estimated fishery catch at age (from landings and estimated discards at age) of American plaice from NAFO Div. 4T, 1976 to 2015. The age 16+ is a plus group.

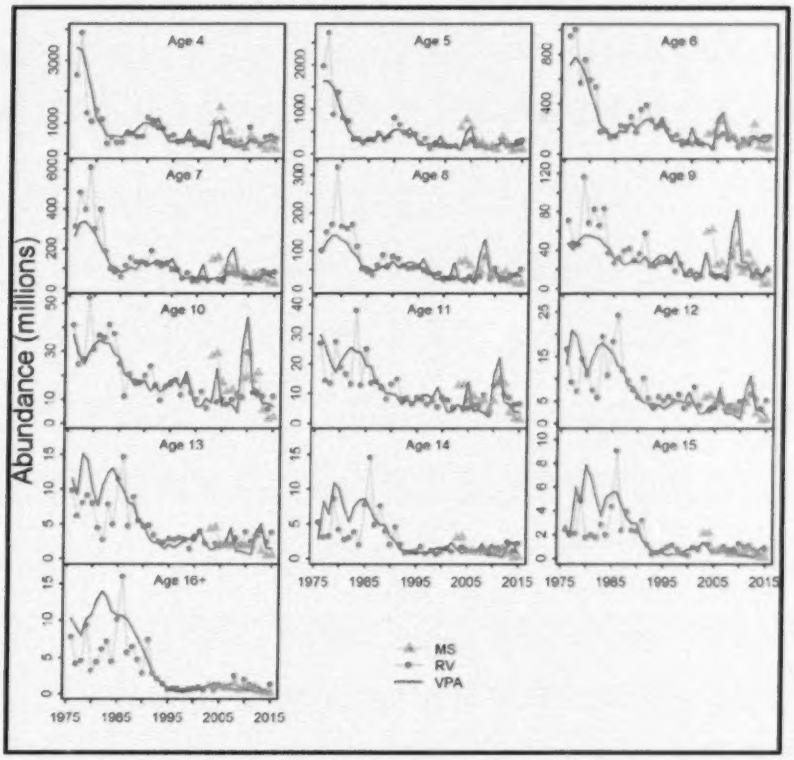


Figure 10. Comparison of model derived estimates of abundance (millions) of ages 4-16+ American plaice from the VPA model (red lines) and from the survey populations in September, corrected for RV survey catchability (blue solid lines with blue dots) and sentinel survey catchability (green solid lines with green triangles).

Natural mortality (*M*) for American plaice ages 4 to 9, was estimated to have decreased from about 0.75 (53% per year) in the late 1970s to about 0.50 (39% per year) since 2005 (Fig. 11). This contrasts with the estimated natural mortality for plaice aged 10+ for which *M* was estimated to have been about 0.25 (22% per year) in the 1970s and rising rapidly to greater than 0.50 (39% per year) since 1995 (Fig. 11). Natural mortality for age 10+ plaice is estimated to exceed that for plaice 4 – 9 years, since 2008. Fully recruited fishing mortality on age 10+ was estimated to have peaked in 1992 at just over 0.3 but has been less than 0.01 in the recent five years (Fig. 11).

The median estimate of spawning stock biomass (SSB) was about 350 kt in the late 1970s decreasing rapidly to 100 kt or less by 1984 (Fig. 12). Estimated SSB has varied between 50,000 and 80,000 t since 1995 and was estimated at 55,000 t in 2015 (Fig. 12). Recruitment abundance has varied from 4 billion fish at the start of the time series to 170 million fish at its lowest point in 2002.

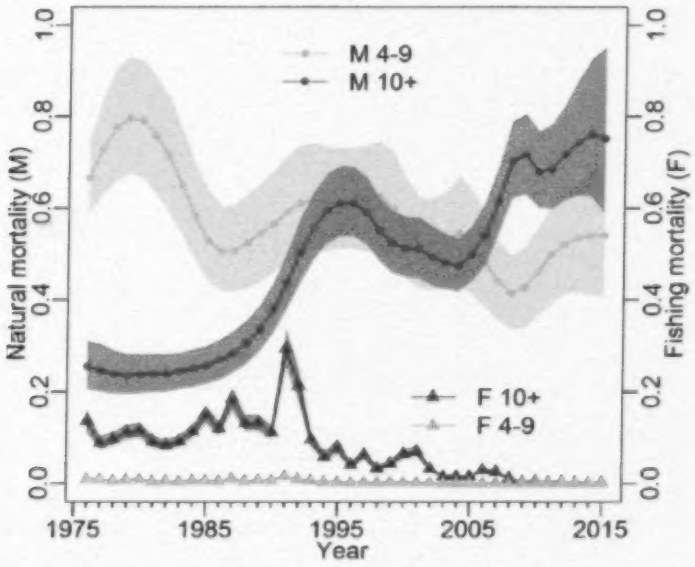


Figure 11. Estimates of natural mortality and fishing mortality rates for ages 4-9 and ages 10+ of American plaice of the sGSL from the VPA model to 2015. The solid lines and symbols are the median and the shading encompasses the 95% credibility interval of the estimates.

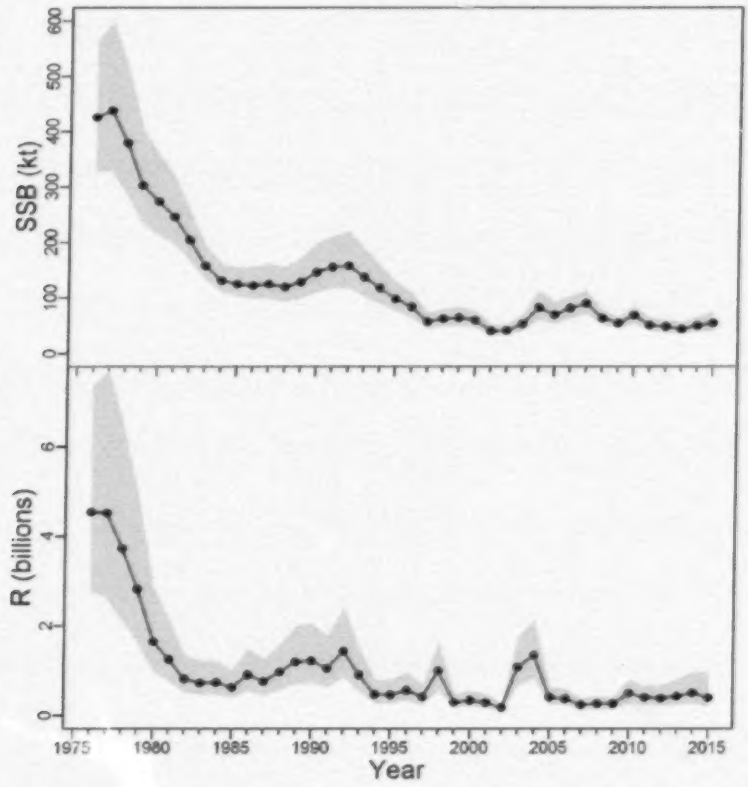


Figure 12. Estimated spawning stock biomass (SSB; kt, upper panel) and estimated recruitment at age 4 (billions, lower panel) of American plaice of the sGSL, 1976 to 2015. The black line is the median and the shading encompasses the 95% credibility interval of the estimates.

Reference points for American plaice NAFO Div. 4T

The limit reference point (LRP; B_{lim}) for American plaice from NAFO Div. 4T is defined as the SSB that produced 50% of maximum recruitment at age 4 years (DFO 2012; Morin et al. 2012). The B_{lim} value from that assessment was 64 kt (DFO 2012). As a result of the changes in the population dynamics model used and with the updated and extended time series, the B_{lim} value was re-estimated using a Beverton-Holt stock-recruitment model at 139 kt (median value) (Fig. 13). The 95th percentile of the estimated SSB from the population model has been below B_{lim} and the stock has been in the critical zone since 1993. In 2015, the median of the SSB estimate was 40% of B_{lim}, with essentially zero chance of being above B_{lim} (Fig. 13).

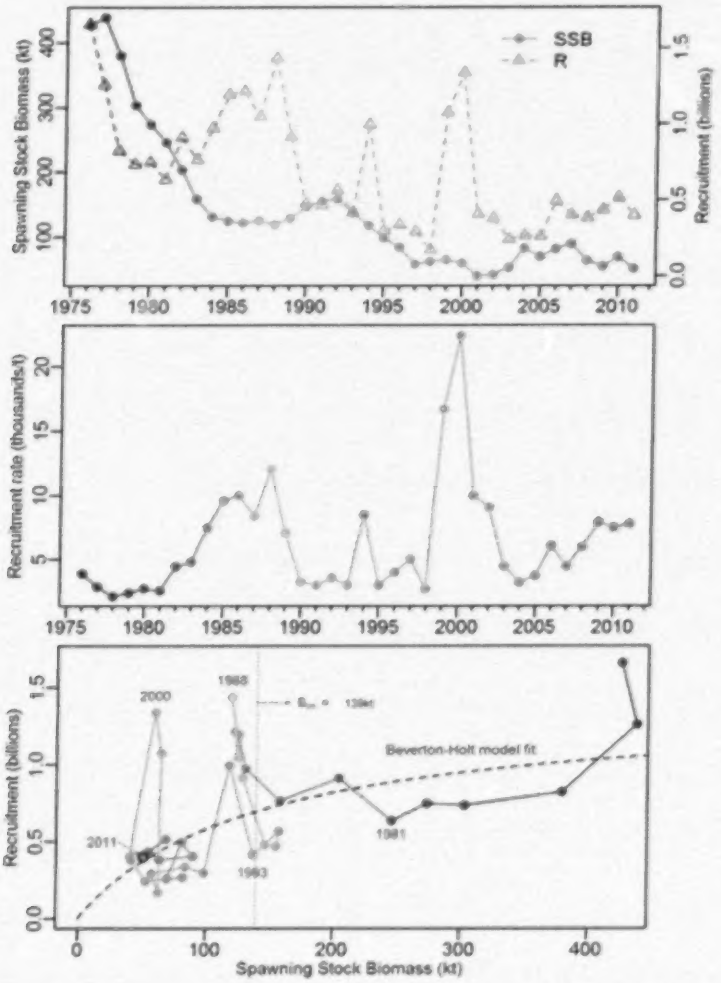


Figure 13. Spawning stock biomass (kt) and recruitment at age 4 (number, billions) dynamics of American plaice of the sGSL. The top panel shows the time-series of spawning stock biomass (shaded circles) and recruitment (open triangles). The recruitment time-series is lagged to match the spawning stock biomass that produced it (i.e. the age at recruitment of 4 years). The time-series of recruitment rate (middle panel) is expressed as the number of recruits per unit of spawning stock biomass (number in thousands per t). The relationship between spawning stock biomass and recruitment and the corresponding fitted curve appears in the bottom panel. In all cases, the years are colour coded from blue (early years) to red (recent years).

Projections relative to different catch levels

The fitted population model under current (most recent five years) productivity conditions (*M*, weight at age, maturity at age, recruitment rate) was used to project the SSB for 2016 to 2021 for three fishing scenarios: annual TACs of 0 t, 100 t, and 250 t. Under current conditions, the SSB is expected to remain in the critical zone (with > 95% chance of being below B_{lim}) during 2016 to 2021 at all annual TAC options (Fig. 14). Fishing mortality is a very small proportion of

the total mortality of American plaice of the sGSL. The rebuilding prospects for this stock under current conditions are low because of the high level of natural mortality.

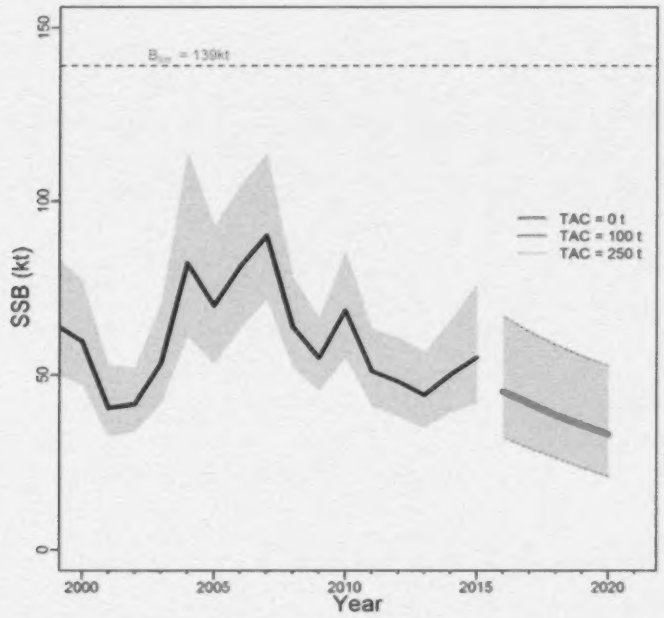


Figure 14. Spawning stock biomass (SSB; 1999 to 2015, solid line and grey shading) and projections of SSB (2016 to 2021; dotted line and red shading) for American plaice of the sGSL for annual TAC options of 0 t, 100 t, and 250 t. The solid lines are the median and the shading areas encompass the 95% credibility interval of the estimates.

Sources of Uncertainty

As the fishery declined in size, there are fewer samples from the fishery with which to characterize the size and age structure of the catches. However, as total landings are small and the estimated fishing mortality is very small, the consequences of this to assessing stock status are negligible.

A large portion of the now small level of catches of American plaice is reported as bycatch in the Greenland halibut gillnet fishery in NAFO Subdiv. 4To. Samples from that fishery have been sparse because it is a bycatch fishery and individual samples from observers are of very small numbers for length with fewer samples of otoliths to determine age. Obtaining additional commercial samples from the observers and from port sampling would be beneficial to improve the generation of the catch-at-age matrices from this fishery as well as from the other component of the landings coming from mobile gear. However, due to the small catch level, the consequences to the assessment are not considered important.

The indices of abundance are limited to the southern Gulf portion of NAFO Div. 4T and exclude the lower estuary western portion of Div. 4T, where plaice also occur and are fished. If there has been a shift in distribution between these areas, the perception of trends in stock size of the Div. 4T stock may be biased. This could be confirmed by examining the available data from the southern Gulf survey and the data from the northern Gulf survey, which covers the area outside of the southern Gulf survey.

The trends in abundance derived from RV survey decline less rapidly than the indices from the mobile sentinel survey. The reasons for this difference are not fully understood but could be due to differences in gear used and the larger number of uncalibrated vessels in this survey over the time series. This conflicting information impacts recent estimates of *M* and stock size but has little impact on the perception of overall stock status.

Maturity at age in a large portion of the age matrix is assumed to be constant over time, due to limited information on maturation schedules. In recent years, the maturity at age is also uncertain due to staging difficulties and recording at sea. Adjustments to the values in the time series are not possible, but improvement to staging and recording in the future should be pursued. If maturity at age has varied over time, this may have consequences on the estimates of SSB and on the estimation of reference points.

The model used in this assessment had an important retrospective pattern in the estimates of natural mortality for American plaice age 10+ in the recent period, and a retrospective effect over the entire time series of estimates of natural mortality of the 4-9 years age group. This produces large differences in the revised values of SSB, recruitment, and mortality rates through time. As a result, there are consequences to the estimation of reference points and perspectives on stock status over the entire time series. In relative terms (SSB as a proportion of B_{lim}), the conclusions on stock status in recent years are not changed as a result of the retrospective pattern with the SSB being well below the limit reference point. Alternate parameterizations for the population model or alternate models that would reduce or eliminate the retrospective pattern should be examined.

CONCLUSIONS AND ADVICE

American plaice of the sGSL was once an abundant resource. In the 1980s, it was the most important commercial flatfish fishery in the sGSL at reported landings of 5,000 to 9,000 t annually. Since then, American plaice landings have steadily declined and in recent years have been at their lowest historical level. The preliminary reported landings in 2015 were 40 t. The low landings of American plaice in 2012 to 2015 were reported primarily as by-catch in the witch flounder fishery by mobile gear off Cape Breton and the Greenland halibut fishery exploited by gillnetters off the Gaspe coast.

The RV survey biomass index for pre-commercial sized (< 30 cm) American plaice increased sharply between 1971 and 1977 but declined afterward to the lowest values of record in the early 2000s. Abundance indices in 2015 remained below the long term average value. The same trend in abundance was noted for commercial sized American plaice (>= 30 cm), with the value in 2015 slightly improved from 2012 but remaining well below the long term mean value.

Size of American plaice caught in the September research vessel bottom trawl survey has declined, with mean lengths in 1971 to 1995 between 25 and 26 cm, decreasing to a mean value of 21.3 cm during the 2011 to 2015 time period. Large plaice greater than 40 cm continue to be captured in the sGSL in September, although the percentage of the sampled catches has declined from almost 5% in the early 1970s to less than 1% by 2001.

Size at age of American plaice in the sGSL has declined. The mean weight of American plaice over the period 1976 to 2015 declined by 11% for age 6, 24% for age 8, 37% for age 10 and 55% for age 12 fish.

There is no apparent change in the spatial distribution of American plaice in the sGSL over the time series. American plaice of all size groups, both male and female, show sustained broad distribution in the sGSL in September.

The median estimate of spawning stock biomass (SSB) was about 350 kt in the late 1970s decreasing rapidly to 100 kt or less by 1984. Estimated SSB has varied between 50,000 and 80,000 t since 1995 and was estimated at 55,000 t in 2015. Fully recruited fishing mortality on age 10+ was estimated to have peaked in 1992 at just over 0.3 but has been less than 0.01 in the recent five years. Natural mortality for American plaice ages 4 to 9, was estimated to have decreased from about 0.75 (53% mortality per year) in the late 1970s to about 0.50 (39% mortality per year) since 2005. This contrasts with the estimated natural mortality for plaice aged 10+ for which *M* was estimated to have been about 0.25 (22% mortality per year) in the 1970s and rising rapidly to greater than 0.50 (39% mortality per year) since 1995.

A revised limit reference point (B_{lim}) using updated information to 2015 and output from the revised model gives a B_{lim} value of 139 kt. The stock has been in the critical zone, with at least 95% chance, since 1997. In 2015, the median of the SSB estimate was 40% of B_{lim} with essentially zero chance of the SSB being above B_{lim}.

Under current productivity conditions (*M*, weight at age, maturity at age, recruitment rate), the SSB is expected to remain in the critical zone with essentially zero chance of the SSB being above B_{lim} during 2016 to 2021 at TAC options of 0 t, 100 t, or 250 t. Fishing mortality is a very small proportion of the total mortality of American plaice of the sGSL. The rebuilding prospects for this stock under current conditions are low because of the high level of natural mortality. The causes of the high *M* are not fully known but available evidence supports the hypothesis that predation by grey seals is a major component of this increased natural mortality (Swain and Benoît 2015).

OTHER CONSIDERATIONS

Stock status indicators

The three-year moving average of the RV survey biomass indices for commercial-sized plaice (>= 30 cm) will be used as the indicator of stock status in the interim years of the multi-year management cycle. This index will be compared to the LRP value adjusted to the scale of the biomass index which is itself not corrected for catchability. The re-scaled LRP is 33,770 t of trawlable biomass in September or 19.5 kg/tow. An assessment before the scheduled five-year cycle would be recommended if the three-year moving average of the RV biomass index for commercial-sized American plaice exceeds the re-scaled LRP of trawlable biomass.

An interim year update will be provided mid-way in the five-year assessment cycle, i.e. in early December 2018, to allow sufficient time to complete a full assessment and plan the peer review if the indicators signal that a re-assessment (i.e. the indicator is at or above the LRP) is warranted in winter 2019.

SOURCES OF INFORMATION

This Science Advisory Report is from the March 1 and 2, 2016 science peer review meeting on the Stock assessment of Amercian Plaice (*Hippoglossoides platessoides*) of the southern Gulf of St. Lawrence (Northwest Atlantic Fisheries Organization (NAFO) Division 4T). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

Benoît, H.P. 2006. Standardizing the southern Gulf of St. Lawrence bottom-trawl survey time series: results of the 2004-2005 comparative fishing experiments and other recommendations for the analysis of the survey data. DFO Can. Sci. Advis. Sec. Res. Doc. 2006/008: 127 p.

Benoît, H.P., and Swain, D.P. 2003. Standardizing the southern Gulf of St. Lawrence bottom-trawl survey time series: adjusting for changes *in* research vessel, gear and survey protocol. Can. Tech. Rep. Fish. Aquat. Sci., 2505: iv + 95 p.

DFO. 2011. Recovery Potential Assessment of the Maritime Designatable Unit of American Plaice (*Hippoglossoides platessoides*). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/043.

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DFO. 2015. Updated indices of abundance to 2014 for stocks of six groundfish species assessed by DFO Gulf Region. DFO Can. Sci. Advis. Sec. Sci. Resp. 2015/015.

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Savoie, L. 2016. Indices of abundance to 2014 for six groundfish species based on the September research vessel and August sentinel vessel bottom-trawl surveys in the southern Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/085. v + 52 p.

Swain, D.P., and Benoît, H.P. 2015. Extreme increases in natural mortality prevent recovery of collapsed fish populations in a Northwest Atlantic ecosystem. Mar. Ecol. Prog. Ser. 519: 165-182.

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Aussi disponible en français :

MPO. 2016. Évaluation du stock de plie canadienne (Hippoglossoides platessoides) du sud du golfe du Saint-Laurent (division 4T de l'OPANO) jusqu'en 2015. Secr. can. de consult. sci. du MPO, Avis sci. 2016/031.